



**Catalytic cracking process and apparatus therefor**

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**Abstract of GB859246**

Apparatus for the catalytic cracking of hydrocarbons wherein the catalyst is dispersed in the fluidising gas and carried cocurrently with it, comprises a tubular fluidisation section above which is an outwardly diverging conical transition section (angle of divergence within the range 0.5 to 2.5 degrees) above which in turn is a tubular cracking section, the total length:average diameter ratio of the transition and cracking sections being within the range of 10:1 to 20:1; the apparatus also comprises first conduit means at the bottom of the fluidisation section for injecting a gaseous fluidising medium, second conduit means downstream from the first for introducing finely-divided solids into the fluidisation section, and injection means downstream from the second conduit means for injecting a liquid feedstock into this section. Preferably the top diameter of the transition section is 2-3 times the bottom diameter thereof. The apparatus is suitable for the catalytic cracking of a petroleum hydrocarbon gas oil fraction, boiling within the range 650-1050 DEG F. and containing at least 30% volume of components boiling above about 800 DEG F., the catalyst, substantially unfluidised, is introduced into the second conduit means at 1100-1250 DEG F. and is fluidised by a gas introduced through the first conduit means, the feedstock being injected in liquid condition through the injection means in an amount providing for a catalyst:oil ratio of 5-20:1 and the total suspension of catalyst in volatilized feedstock components flowing upwards through to transition section; said suspension may be at a superficial gas velocity of 8-50 feet per second at the top of said section, the suspension then flowing through the cracking section at not less than the superficial gas velocity referred to. In general, the reaction temperature is 850-1000 DEG F. Optionally, additional feedstock of a more refractory nature may be injected through a plurality of nozzles situated downstream from the normal injection means.

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# PATENT SPECIFICATION

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DRAWINGS ATTACHED

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## COMPLETE SPECIFICATION

### Catalytic Cracking Process and Apparatus Therefor.

We, ESSO RESEARCH AND ENGINEERING COMPANY, a Corporation duly organised and existing under the laws of the State of Delaware, United States of America, of Elizabeth, New Jersey, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention is directed to the fluidized disperse phase catalytic cracking of hydrocarbons.

In accordance with the present invention, there is provided apparatus for the fluidized catalytic cracking of hydrocarbons comprising a lower tubular fluidization section, an outwardly-diverging conical transition section above the fluidization section having an angle of divergence within the range of  $0.5^{\circ}$  to  $2.5^{\circ}$  and a tubular cracking section above the transition section, the total length-to-average diameter ratio of the transition section and the cracking section being within the range of 10:1 to 20:1, first conduit means at the bottom of the fluidization section for injecting a gaseous fluidizing medium therein, second conduit means downstream from the first conduit means, for introducing a finely divided solids into the fluidization section, and injection means downstream from the second conduit means, for injecting a liquid feedstock into the fluidization section.

On using the apparatus according to this invention the cracking catalytic is heated to a temperature in excess of the temperature to be maintained in the reaction zone and is introduced through the second conduit [Price 3s.6d.]

means adjacent the bottom of the fluidization section and brought into contact firstly with an amount of fluidizing gas sufficient to initiate fluidization of the catalyst and secondly with a high velocity stream of a liquid hydrocarbon feed stock which is at a temperature below the desired reaction temperature to be maintained in the reaction zone. The amount of catalyst and amount of feed stock injected into the fluidization zone are proportioned so as to provide for a desired catalyst-to-oil ratio within the reaction zone and the temperatures of the hot fresh catalyst and of the liquid feed stock are adjusted to provide for substantially complete volatilization and heating of the feed stock by direct heat exchange contact with the hot catalyst to a desired reaction temperature within the range of  $850^{\circ}$  to  $1000^{\circ}\text{F}$ .

As a consequence, there is formed within the fluidization section of the reaction zone a suspension of conversion catalyst in the gaseous hydrocarbon feed stock whereby a conversion reaction is initiated. The thus-formed suspension is flowed upwardly through an outwardly diverging conical transition section at a progressively increasing velocity such that retrograde movement of the fluidized catalyst relative to the wall of the acceleration (transition) zone is substantially completely inhibited. The vaporized hydrocarbon and suspended catalyst are accelerated to an extent sufficient to provide for a disperse phase suspension of catalyst in vaporized hydrocarbon feed stock components at the upper end of the acceleration (transition) section. The thus-formed disperse phase

suspension is thereafter flowed through the conversion section at a velocity not less than the velocity of the suspension at the upper end of the acceleration (transition) zone to obtain a desired degree of conversion of the hydrocarbon feed stock components.

Referring to the accompanying drawing, there is disclosed a reaction zone A, a separation zone B, and a regeneration zone C. The reaction zone A comprises a lower initial fluidization section designated generally by the numeral 10, and comprising a first boot section 12 and a second boot section 14. Above the fluidization section 10 is an outwardly diverging transition section 16 according to the invention interconnecting the fluidization section 10 with a conversion section 18. The diameter of the top of the transition section is preferably from 2 to 3 times the diameter of the bottom thereof. A conduit 20 is provided at the outlet end of the conversion zone A for transporting spent catalyst and conversion products to the separation zone B which may comprise, for example, an upper stripping section 22 provided internally with a plurality of cyclone separators (not shown) for separating gaseous components of the conversion product from the spent catalyst. Conversion products are discharged from the top of the separation zone 22 by way of a conduit 24 leading to suitable means (not shown) for the recovery and separation of the conversion products. The separation zone B may be provided with a lower stripping zone 26 containing a plurality of baffles 28 and further provided adjacent the bottom thereof with a plurality of injection nozzles 30-30 for the introduction of a gaseous stripping medium into the stripping zone 26. Within the stripping section 26 the spent catalyst is contacted with the inert gaseous stripping medium whereby conversion products are substantially completely separated from the spent catalyst.

The spent catalyst is discharged from the stripping section 26 by way of a conduit 32 leading to the regeneration zone C wherein the catalyst is regenerated. Thus, the spent catalyst may be formed into a dense phase suspension of catalyst in a turbulently generally upwardly flowing stream of air whereby carbonaceous deposits will be burned from the spent catalyst and the temperature of the catalyst will be raised to a desired predetermined temperature within the range of 1100° to 1250°F.

Regenerated catalyst is collected in funnel 40 adjacent the bottom of the regeneration zone C and flowed under the influence of gravity through a conduit 42 to the lower boot section 12 of the fluidization section 10 of the reaction zone A.

The present invention is of particular utility with respect to the catalytic cracking of heavy hydrocarbon feed stocks containing more than 30 volume per cent of hydrocarbon components boiling above about 800°F. Feed stocks which may be advantageously treated in accordance with the present invention comprise heavy gas oil fractions boiling within the range of 650° to 1050°F. Such feed stocks are volatilized only with difficulty in that they are prone to thermal cracking when slowly heated to a volatilization temperature. Moreover, such feed stocks are comparatively refractory with respect to catalytic cracking. Still further, such heavy feed stocks normally have a pronounced tendency with respect to coke formation and with respect to formation of excessive amounts of asphaltic materials and hydrogen.

However, in accordance with the present invention, satisfactory conversion of such feed stocks may be obtained without the formation of excessive amounts of coke, asphaltic materials and hydrogen and with the formation of enhanced amounts of valuable gasoline boiling range and heating oil boiling range products.

As a specific example of the manner in which such a heavy feed stock may be catalytically cracked in accordance with the present invention, there may be provided a virgin feed stock fraction boiling within the indicated range which is preheated to a temperature below the temperature of volatilization of lighter components of the feed stock by any suitable means (not shown) and then injected into the inlet end of the lower boot section 12 by way of an injection nozzle 44. The virgin liquid feed component should preferably be injected at a velocity within the range of 20 to 50 feet per second. A gaseous fluidizing medium, which is preferably an inert gas such as steam, is also injected into the base of the lower boot section 12 by way of a line 46. Simultaneously, substantially unfluidized catalyst at a temperature within the range of 1100° to 1250°F. is introduced into the lower boot section 12 by way of the conduit 42.

The steam injected through the

line 46 is introduced in an amount sufficient to fluidize the regenerated catalyst. That is to say, the steam introduced initiates fluidization of the freshly introduced catalyst and provides for a superficial inlet gas velocity within the range of 0.5 to 3 feet per second. The liquid feed stock injected through nozzle 44 is substantially instantaneously volatilized on contact with the fluidized catalyst whereby thermal cracking of the feed stock is substantially completely inhibited during the volatilization step. Volatilization of the feed stock results in rapid acceleration of the fluidized catalyst to provide for a superficial gas velocity within the range of 15 to 40 feet per second whereby there is formed a disperse phase suspension of catalyst in volatilized hydrocarbon feed components. A disperse phase suspension may be defined as a suspension of catalyst particles in a volatilized gaseous fluidization medium having a density of 2 to 16 pounds per cubic foot and a superficial gas velocity sufficient to substantially completely inhibit retrograde movement (that is, to give co-current flow) of catalyst particles relative to the wall of the container.

If desired, an additional quantity of feed stock of a more refractory nature may be injected into the thus-formed suspension and the second boot section 14 by way of a plurality of injection nozzles 48. A more refractory fraction is preferably introduced by injection nozzles 48, such as a recycle fraction obtained by the fractionation of the catalytic cracking products. Thus, the recycle fraction may boil within the boiling range of the feed. Again the recycle fraction is injected at an injection velocity within the range of 20 to 50 feet per second to provide for substantially complete instantaneous mixing of the feed with the hot catalyst whereby substantially instantaneous volatilization of the liquid feed components is obtained.

In the embodiment of the present invention shown in the drawing, the catalyst is not finally cooled to the desired temperature for conversion until after injection of the recycle fraction into the second boot section 14 through the nozzles 48. Therefore, in order to prevent overcracking of the fresh feed in the first boot section 12, it is necessary to minimize the residence time of the fresh feed components in the first boot section 12 and to heat the volatilized feed to a temperature not

more than about 50°F. (e.g., 20°F.) higher than the desired cracking temperature. This is readily accomplished when e.g. 50 to 80 volume per cent of the total feed is introduced into the first boot section 12 through the nozzle 44 and when the remaining 50 to 20 volume per cent of the total feed is introduced into the second boot section 14 through the nozzles 48.

The disperse phase suspension of fluidized cracking catalyst and volatilized hydrocarbons next passes through the diverging conical transition section 16. The fluidized suspension should be flowed through the acceleration (transition) section 16 in a manner to substantially prevent retrograde movement of catalyst particles relative to the wall of the acceleration section 16. This is accomplished by providing for an angle of divergence within the acceleration section 16 within the range of 0.5° to 2.5°.

Extending above the acceleration (transition) section 16 is a conversion section 18 of substantially uniform cross-sectional area wherein relatively more refractory feed stock components are catalytically cracked, the length of the reaction section 18 being determined, in part, by the degree of conversion to be obtained.

The conversion conditions to be maintained in the reaction zone A include in general, a reaction temperature within the range of 850° to 1000°F., a reaction pressure within the range of 5 to 30 psig, a catalyst-to-oil ratio within the range of 5 to 20, and a length-to-average diameter ratio for the combined transition section 16 and the conversion section 18 sufficient to provide for a contact time within the range of 5 to 30 seconds. Accordingly, the length-to-average diameter ratio for the combined transition section 16 and the reaction section 18 should be within the range of 10:1 to 20:1 in order to obtain a conversion of the feed stock within the range of 40 per cent conversion to 70 per cent conversion.

#### WHAT WE CLAIM IS:

1. Apparatus for the fluidized catalytic cracking of hydrocarbons comprising a lower tubular fluidization section, an outwardly diverging conical transition section above the fluidization section having an angle of divergence within the range of 0.5° to 2.5° and a tubular cracking section above the transition section, the total length-to-average diameter ratio of the transition section and the cracking section being within the range of 10:1 to 20:1, first

conduit means at the bottom of the fluidization section for injecting a gaseous fluidizing medium therein, second conduit means downstream from the first conduit means, for introducing finely divided solids into the fluidization section, and injection means downstream from the second conduit means, for injecting a liquid feed stock into the fluidization section.

2. Apparatus as claimed in Claim 1 wherein the top diameter of the transition section is from 2 to 3 times the bottom diameter thereof.

3. A method using the apparatus as claimed in Claim 1 or Claim 2 for the disperse phase fluidized catalytic cracking of a petroleum hydrocarbon gas oil fraction boiling within the range of 650° to 1050°F and containing at least 30 volume per cent of components boiling above about 800°F, comprising introducing finely divided cracking catalyst into the said second conduit means in a substantially unfluidized condition at a temperature within the range of 1100° to 1250°F, fluidizing the catalyst with an inert gaseous fluidization medium introduced through the said first conduit means to

form a dense phase suspension, injecting the feed stock in liquid condition through the said injection means in an amount sufficient to provide for a catalyst-to-oil ratio within the range of 5 to 20, and whereby the feed stock is volatilized, flowing said total suspension upwardly through the said transition section whereby the suspension of catalyst in volatilized feed stock components is at a superficial gas velocity within the range of 8 to 50 feet per second at the top of said transition section and thereafter flowing the thus-formed suspension through the said tubular cracking section at a superficial gas velocity not less than the superficial gas velocity of the suspension at the outlet end of the transition section.

4. Apparatus and processes for the fluidized catalytic cracking of hydrocarbons, substantially as hereinbefore described and illustrated in the accompanying drawing.

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